DOCUMENT RESUME

ED 402 189 SE 059 473

AUTHOR Lindsay, Margaret
TITLE Teaching Chemical Bonding: A Resource Book for Senior Chemistry.
REPORT NO ISBN-0-646-26277-7
PUB DATE 95
NOTE 51p.; Book accompanied by a cassette tape of songs not available from EDRS.
AVAILABLE FROM Excellence in Teaching, 7 Kooba Avenue, Chatswood, New South Wales 2067, Australia.
PUB TYPE Guides - Classroom Use - Teaching Guides (For Teacher) (052)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Chemical Bonding; Chemistry; *Educational Strategies; Foreign Countries; Lesson Plans; Music; Secondary Education; *Short Stories; Teaching Methods

ABSTRACT

This document presents an instructional strategy for teaching chemical bonding using parables and music. Games, student interactions, and worksheets are included in the lesson plans. Topics include metallic bonding, covalent bonding including molecular and network structure, and ionic bonding. (JRH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 402 189

TEACHING CHEMICAL BONDING

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
M. Lindsay
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
X This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

a Resource Book for Senior Chemistry

by Margaret Lindsay

BEST COPY AVAILABLE

SE 054 473

Teaching using parables - not a new idea.

Mark 4: 33-34

With many such parables he spoke the word to them, as they were able to hear it; he did not speak to them without a parable, but privately to his own disciples he explained everything.

Matthew 7:28-29

And when Jesus finished these sayings, the crowd were astonished at his teaching, for he taught them as one who had authority, and not as their scribes.

Thanks to Annette Cam for her inspiration

© The purchaser of this book may photocopy the material for use in the school and class only. Other educational uses may be authorised by the author.
Additional copies may be obtained from **Excellence in Teaching.**

ISBN 0-646-26277-7

Text by Margaret Lindsay
15A Northcote Rd, Hornsby NSW 2077
Ph (02) 476-4738

Cartoons by Vivienne M.L.O. Jones Ph (02) 4873775

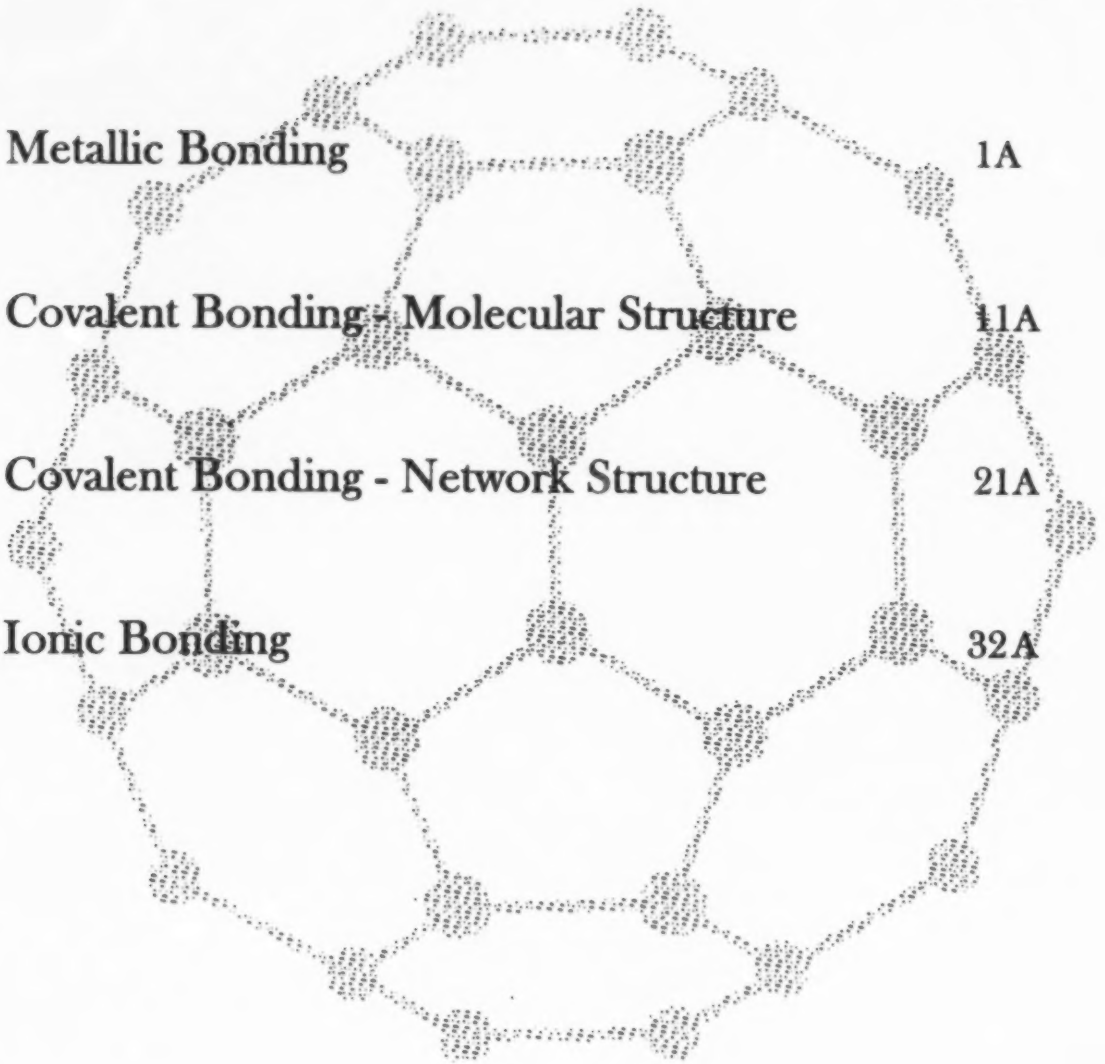
Raps recorded by Lauren Mesiti Mt St Benedict College

Rap recording done by **Sounds of the Street** PO Box 324 Kings Cross NSW 2011
Ph (02) 357 1144 Fax (02) 356 4452

Fanfares can be found on tape 3 of
How to use Music in Teaching and Training by Eric Jensen
available from Excellence in Teaching
7 Kooba Avenue Chatswood NSW 2067 Ph/Fax: (02) 419 3340

Contents

	page
Metallic Bonding	1A
Covalent Bonding - Molecular Structure	11A
Covalent Bonding - Network Structure	21A
Ionic Bonding	32A



Metallic bonding - Suggested Sequence

- Introductory story read to music. (*River* by Enya on the *Watermark* CD is good). Story takes 5 minutes to read, (maybe longer with putting on overheads). You will need to restart your music part way through or rerecord on another cassette. *Danse Boheme* by Bizet from *Symphony No 1 in C sharp Major (Carmen - Suite No 2)* is also good. Again you should restart the music after reading "the little ones" to make it the correct length.
- Traditional explanation of metallic bonding, using the parable to assist in description.
- Stretch Break. "Tell a Partner". Explaining to another fixes the theoretical work in the mind.
- Students make notes using their textbook. (May be given as homework)
- Colour-in periodic table with examples and "star performer"
- Worksheet. Contains definitions of terms.
- Group game - Metallic Bonding
- Rap summary.

Metallica

a parable of metallic bonding

Once upon a time (about 20 years ago), the government social security decided to set up a new housing estate. This housing estate was made of stationary caravans called "mobile homes". The homes were all identical and made of unpainted aluminium. The vans gleamed brightly in the sun and the locals nicknamed the village "Metallica". In the mobile homes were single parent families. The occupants of the vans were all mothers with several children.

Around the village and between all the vans were footpaths and bicycle tracks and the children of Metallica made full use of these. The little ones had little tricycles or little Flintstone-type cars or peddle cars, and they used to go around from house to house every chance they got on their little vehicles. The teenagers had bicycles and would cycle around the village the whole of their free time. The older kids were mostly unemployed and some of these could afford motorbikes and they too used to vroom around the mobile home village of Metallica.

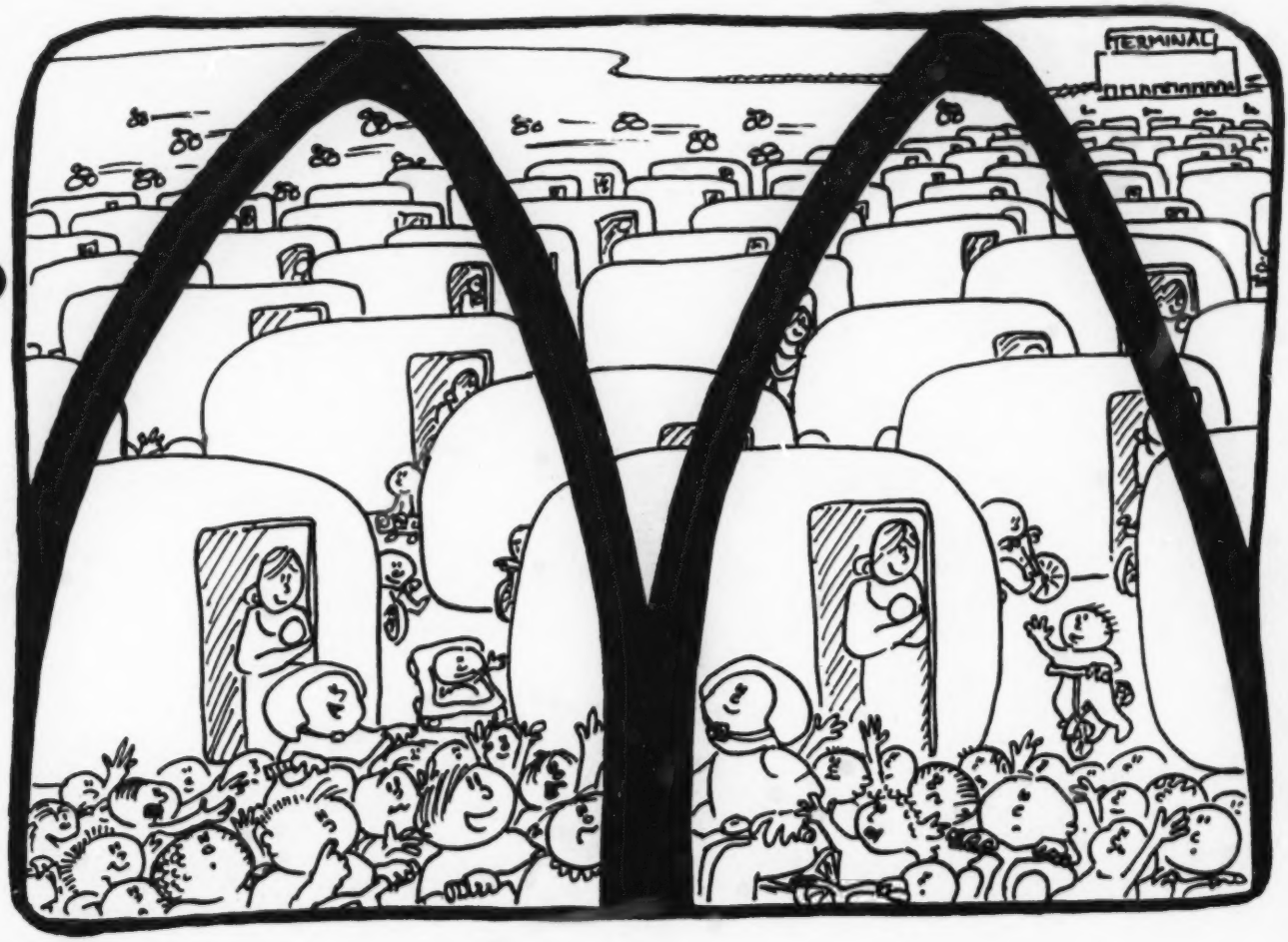
The mothers were rarely seen outside their vans. They were mostly taking care of and breastfeeding their babies inside. The babies were very close to their mothers in Metallica and refused to be babysitted by anyone else.

To the north of the village, there was a train station called Terminal. This was the end of a train line and was rarely used. In fact, the only time trains seemed to come to Terminal was when there was some special occasion or function on at Metallica.

Each evening, when the sun was setting, the mothers of Metallica used to call the kids in for tea. The kids, being hungry from all that cycling around used to stop straight away and come for dinner. However, all the homes were identical, and all the mothers had much the same food, so the kids used to have dinner at whichever home they happened to be closest. The mothers didn't mind because they knew that their own kids were being well looked after probably just a few homes away. In this way the community became very closely knit. All the kids would cycle around the whole village and play around everyone's van and indeed it was said that some of the mothers were not really sure which of the kids belonged to her and which did not.

At the south of the village was a huge McDonalds. It was the biggest in the country and it was the national training headquarters. One day, Macca's had a big promotion on: free hamburgers for a limited time only. This was just at tea time so all the mobile Metallica kids cycled to McDonalds on their bikes, motorbikes or tricycles. *** (overhead illustration)** The babies of course and little toddlers had to stay inside with their mothers and didn't even know that the special offer was on. Trains started arriving at Terminal station bringing in more kids to take advantage of the special offer. Most of these kids had bikes too and started cycling through Metallica to get to McDonalds. Some ran off the train and through the village. Some of them were really pushy and grabbed bikes from Metallica kids then cycled through the village on the bike tracks. The mothers called their kids in for tea and some of these new kids even had dinner in the vans. The mothers were so busy with their work and the little ones they didn't even know that these kids were new kids and weren't even Metallica kids at all! The new kids felt so much at home that some of them even stayed on after the McDonalds special offer finished and became Metallica kids. No one knew that they had never even belonged there!

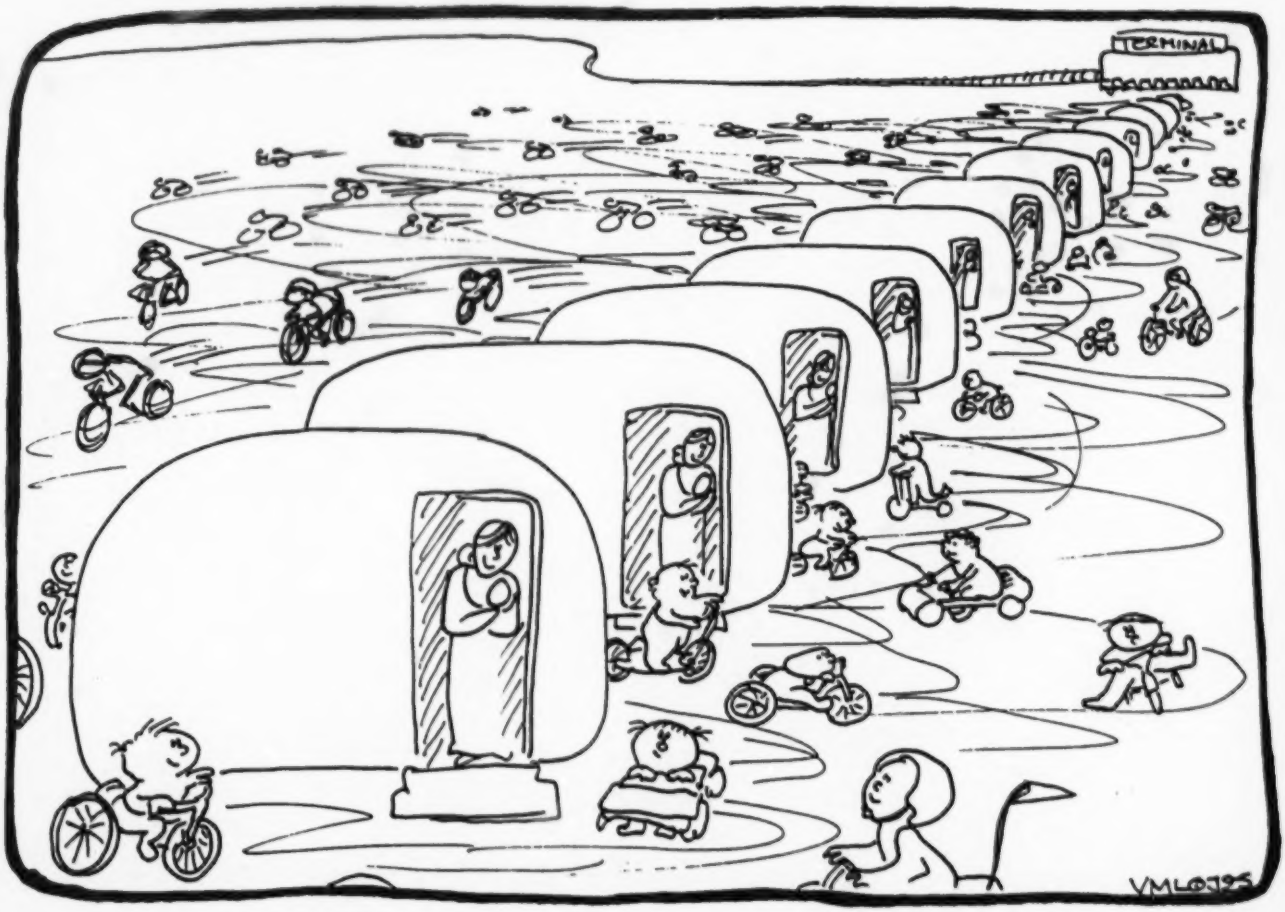
* MOBILE METALLICA KIDS ATTRACTED TO MACCAS



One day the government decided that the housing estate of Metallica, despite being a closely knit and very happy estate, was dysfunctional. The government decided that Metallica would be more functional in a linear arrangement along the highway. They put the mobile homes on big semitrailers and moved them into a line. ** **(overhead illustration)** The mothers and babies refused to leave the vans and remained in them as they were loaded onto to trailers and shifted. The kids and unemployed teenagers protested by cycling around and beside the semitrailers and weaving in and out as their mothers were shifted. When the vans were repositioned they continued riding around on their new bike tracks exactly as before. They were still happy, and as they said to each other - their housing estate had not been dismantled or ruined - they were all still there - still the same happy, closely knit group - just in a different arrangement of vans.

the end

**VANS PLACED IN A LINE



The Explanation

The teacher explains metallic bonding in the traditional way, weaving in the following allegories:
A metal nucleus is like a mother.
The electrons are like the children.
The inner shell electrons which always stay with the nucleus are like the young children and babies who cannot leave their mother.
The valence shell (outer shell) electrons of a metal are like the older children who are always cycling. They do not stay with any one nucleus, but continually orbit around the metal, thereby providing cohesion within the metal, and preventing it from breaking when it is drawn into a wire - like when Metallica was rearranged along the highway.
The negative electrode which provides additional electrons to the metal is like Terminal station. The attractive positive electrode is like McDonalds. When a current flows, the electrons that arrive at one electrode are not necessarily the electrons that were given to the metal at the negative electrode.

Stretch Break - "Tell a Partner"

YOU NEED
Music - 2-3 minutes fairly lively but played quietly.

You say:

Take a deep breath . Stand up.

In a moment I am going to start some music. While the music is playing I want you to find a person you don't normally sit next to. When the music starts, join that person (if necessary introduce yourself). Explain what you have learnt about metallic bonding to each other.

In two minutes, when the music finishes you are to go back to your normal seat.

Does everyone understand? Are there any questions? Then - let's do it!

Notes from Textbook

Use your regular textbook to make notes on all the points mentioned by the teacher. This may be given as homework.

PHOTOCOPY PAGE

SIMPLIFIED PERIODIC TABLE
METAL QUESTIONS

On the periodic table below

- **Shade in the metals and semi-metals (metalloids)**
- **List the names and symbols of 4 common metals**
- **Indicate the "star performer" i.e. the most metallic metal.**

									1 H								2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr																	

SIMPLIFIED PERIODIC TABLE
METAL QUESTIONS

On the periodic table below

- **Shade in the metals and semi-metals (metalloids)**
- **List the names and symbols of 4 common metals**
- **Indicate the "star performer" i.e. the most metallic metal.**

									1 H								2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr																	

BEST COPY AVAILABLE

Notes on Metal Classification

- not easy when there is a gradation of properties

also see table page 15A

1 Metals are good conductors of electricity and their ability to conduct decreases at higher temperatures. According to this criterion, all those shaded, and antimony as well, (including the lanthanides and actinides) are metals. Antimony has an oxide with acidic and amphoteric properties, and its structure is that of a metallic-like network. Thus it has been included with the semi-metals here.

2 Some authorities include Astatine and/or Polonium as semi-metals. The physical and chemical properties of Astatine are not well known because it is so radioactive. Its structure and conductivity are not known. Its m. pt. is 302°C, its b.pt is 335°C. The longest-lived isotope, ^{210}As, has a half-life of 8.3 hours. Polonium similarly is radioactive and difficult to investigate. Polonium has a metallic structure according to the Data Book (1994 ed). Its m.pt is 254°C, its b pt is 962°C. Its conductivity, at 0.7 MSm^{-1} is low, but some other metals have similar conductivities (Plutonium is 0.7, Manganese is 0.54 MSm^{-1}). In the absence of further data, Polonium has been classified here as a metal, and Astatine as a non-metal.

3 Semi-metals or metalloids are poor conductors of electricity at room temperature, but as the temperature rises, their conductivity increases. According to this criterion, those shaded are semi-metals, but antimony has been included as well.

4 Caesium has the same electronegativity as Francium (both 0.7), but Francium has a lower first ionisation energy (331 kJ/mol vs 356 kJ/mol for Cs), thus Francium is the most metallic element. Difficulties obtaining and working with Francium because of its very radioactive nature make Caesium a good choice as a "star performer" of the metals too.

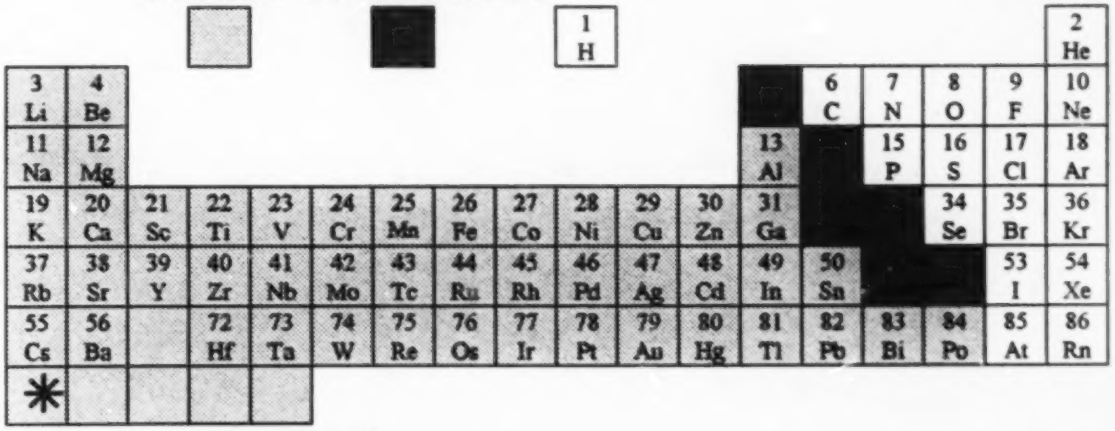
5 Selenium is an insulator in the dark, but conducts quite well in the light!

TEACHER'S PAGE TO MAKE OVERHEAD

SIMPLIFIED PERIODIC TABLE
METAL ANSWERS

Key

Metals semi-metals



																2 He
3 Li	4 Be											6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg										13 Al		15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga		34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn		53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
*																

"star performer"
most metallic metal

Metal Examples choose four but eg.

Copper	**Cu**	**Magnesium**	**Mg**
Zinc	**Zn**	**Iron**	**Fe**

BEST COPY AVAILABLE

NAME _____

Worksheet - Metallic Bonding

Terms to use (may be used more than once)
outer shell electons: ionisation energy: high: conductors: metal ion: shiny: inner shell electrons: mobile: delocalised orbital: malleable: ductile: potential difference: electrode: battery terminal: metallic: positive:negative

Complete the worksheet by filling in the blank spaces

1. Metals have one, two or three _____ _____ _____
2. The nucleus of a metal and its inner shell electrons are termed a _____ _____
3. The electrons that are not given away in bonding are the _____ _____ _____
4. The outer electrons can move around between metal ions i.e. they are _____
5. The outer shell electrons of the metal atoms form a large _____ _____
6. Metals can be hammered into shape without shattering i.e. they are _____
7. Metals are _____- meaning they can be drawn into a wire.
8. The delocalised electrons flow when a _____ _____ is put across the metal.
9. Electrons flow from the negative_____ _____.
10. Electrons are attracted to the _____ electrode.
11. Metals are good _____ of electricity and heat.
12. Cesium and Francium have very low _____ _____.
13. Cesium and Francium are the most _____ of elements.
14. Common examples of metals are _____ , _____, _____, _____ .
15. Metals conduct by the movement of _____ from the _____ electrode to the positive _____.
16. Properties of metals are_____state at room temperature, _____ density, _____lustre, _____, _____, _____ of an electric current when solid or liquid.

BEST COPY AVAILABLE

Worksheet Answers - Metallic Bonding

Complete the worksheet by filling in the blank spaces

1. Metals have one, two or three **outer shell electrons**
2. The nucleus of a metal and its inner shell electrons are termed a **metal ion**
3. The electrons that are not given away in bonding are the **inner shell electrons**
4. The outer electrons can move around between metal ions i.e. they are **mobile**
5. The outer shell electrons of the metal atoms form a large **delocalised orbital**
6. Metals can be hammered into shape without shattering i.e. they are **malleable**
7. Metals are **ductile**- meaning they can be drawn into a wire.
8. The delocalised electrons flow when a **potential difference** is put across the metal.
9. Electrons flow from the negative **battery terminal**.
10. Electrons are attracted to the **positive** electrode.
11. Metals are good **conductors** of electricity and heat.
12. Cesium and Francium have very low **ionisation energy**.
13. Cesium and Francium are the most **metallic** of elements.
14. Common examples of metals are **copper, iron, magnesium, zinc** .
15. Metals conduct by the movement of **electrons** from the **negative** electrode to the positive **electrode.**
16. Properties of metals are **solid** state at room temperature, **high** density, **shiny** or **metallic** lustre, **malleable**, **ductile**, **conductors** of an electric current when solid or liquid.

BEST COPY AVAILABLE

Group Game - Metallic Bonding

Needed - per group of 5

thing to throw e.g. big soft ball, soft ring, bean bag
large piece butchers' paper
coloured textas

What they do

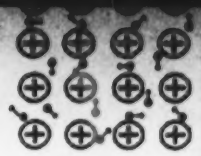
Student group of five gathers around the piece of paper.
Tear off the corners to make it a rough octagon or polygon in shape, with no obvious orientation.
Words/phrases are to be written down in big print with no special orientation.
Students take it in turns to write a significant or important word or phrase from the topic.
As each word is written down the students agree on the definition of the word or phrase.
When about 15 terms are written down, the paper is placed on the floor with the students standing around it.
The person starting with the ball states a term, gives its definition then chooses another term and throws the ball to a person of his choice.
The next person gives the definition, then chooses another term and throws the ball to a person of his choice, who repeats the process.
No repetitions are allowed. Give everyone a turn.
The game is finished when all terms have been used.

Suggested Terms & Important Points

(but students can look up their worksheets)

outer shell electrons
metal ion
inner shell electrons
mobile
delocalised orbital
malleable
ductile
potential difference
battery terminal
electrode
positive
conductor
most metallic metal
ionisation energy
4 Examples
how a metal conducts
4 properties of metals

BEST COPY AVAILABLE



Metallic Rap

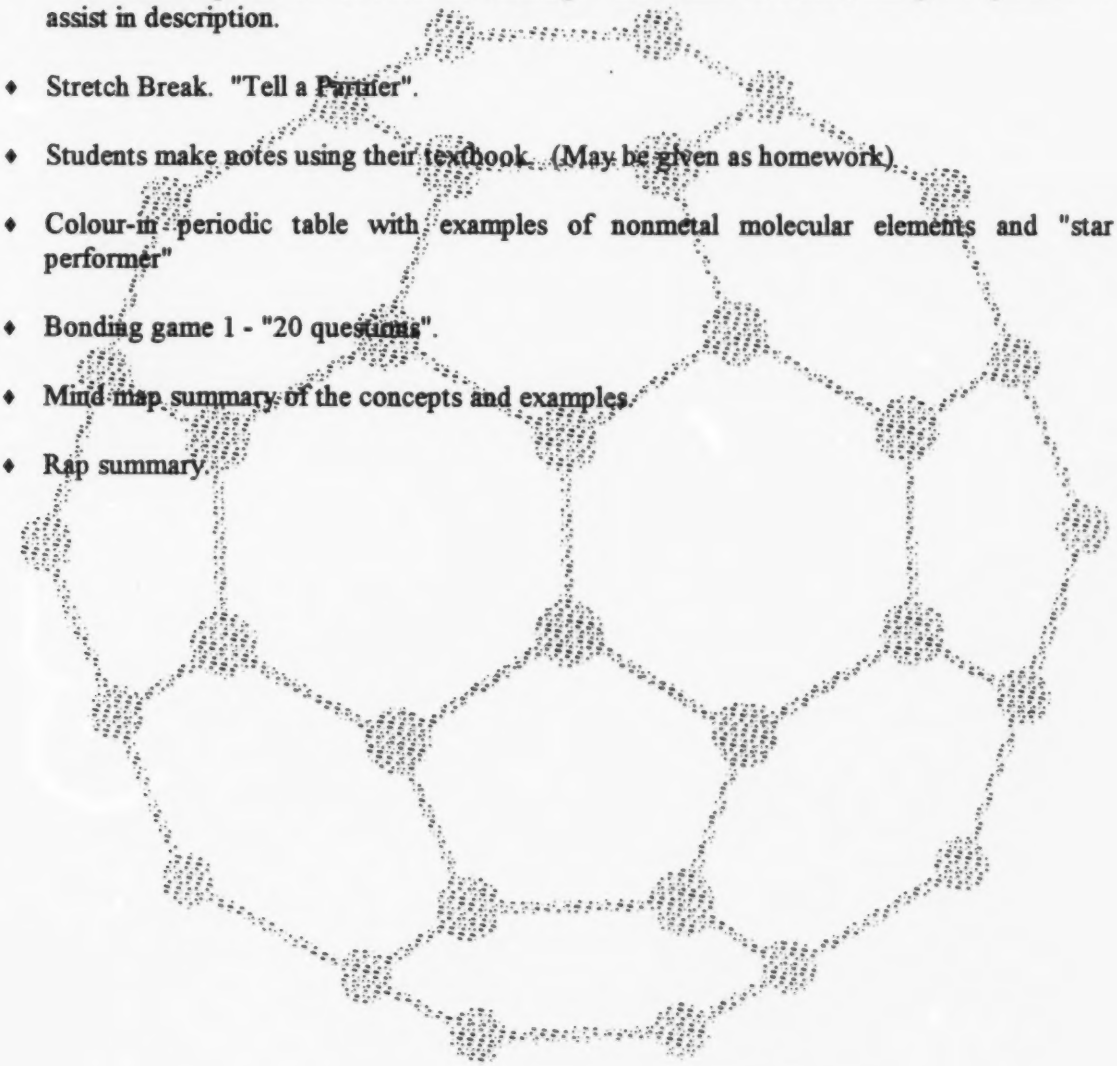
Metallic ions- positive charge -
Share valence electrons - negative charge
Metallic bonding is what we find
Elements only - no compound kind
Electrons move in a mobile sea
To make a communal property
Conduct in a solid or a liquid state
Hey! This bonding is really great!
They're mostly solids at 25 C
And they have a high density
Malleable shiny and ductile -
We know these properties are worthwhile!

Accompany with **clap-slap thighs** rhythm, and the tape.
Try it standing/dancing or marching.

BEST COPY AVAILABLE

Covalent bonding - molecular structure
Suggested Sequence

- Introductory story read to music. (Albinoni *Largo* from *Opus 2 No5* or Pachelbel's *Canon* is good)
- Traditional explanation of covalent bonding - molecular structure, using the parable to assist in description.
- Stretch Break. "Tell a Partner".
- Students make notes using their textbook. (May be given as homework).
- Colour-in periodic table with examples of nonmetal molecular elements and "star performer"
- Bonding game 1 - "20 questions".
- Mind map summary of the concepts and examples.
- Rap summary.



Double Orthodox Wedding

a parable of covalent molecular bonding

Heidi and Hylda were going to make lovely brides their mother thought. Such a pity their dad couldn't be here to see this day, she thought. Heidi looked so nice in her white dress and her twin sister Hylda was equally as lovely as her bridesmaid and a bride in her own right- also in a white dress in the custom of the old country.

The time arrived for the wedding and Heidi and Hylda escorted each other down the aisle arm in arm. The twins girls were both so beautiful and so much alike, each with a bridal circlet of flowers like a little crown on her head. From each circlet hung many long colourful ribbons that fell down the back of each girl.

Heidi's groom, Brom, was waiting for her at the front of the old church. He, too, wore a circlet of flowers with long colourful ribbons and stood arm in arm with his twin brother Ian, Hylda's husband-to-be, who had a similar colourful head-dress.* **(overhead illustration)**

Heidi and Brom stood side by side. The priest began the ceremony in the traditional old words. They held hands. Brom and Heidi exchanged rings. Hylda and Ian then assisted in the final part of the ceremony. The ribbons were tied together one by one. The priest then pronounced that they were man and wife. They were legally joined and indeed even physically bound together by the ribbons. In the traditions of the old country, they would be named Heidi-Brom from that time forward.

Hylda was then wed to Ian. This time Heidi and Brom performed the bridesmaid and best man duties by tying together the ribbons.

Both newly-wed couples then left the church to the peal of bells - ready and happy to start their new lives together - not as separate people but as couples recognised by the community as new families, each with a new name.

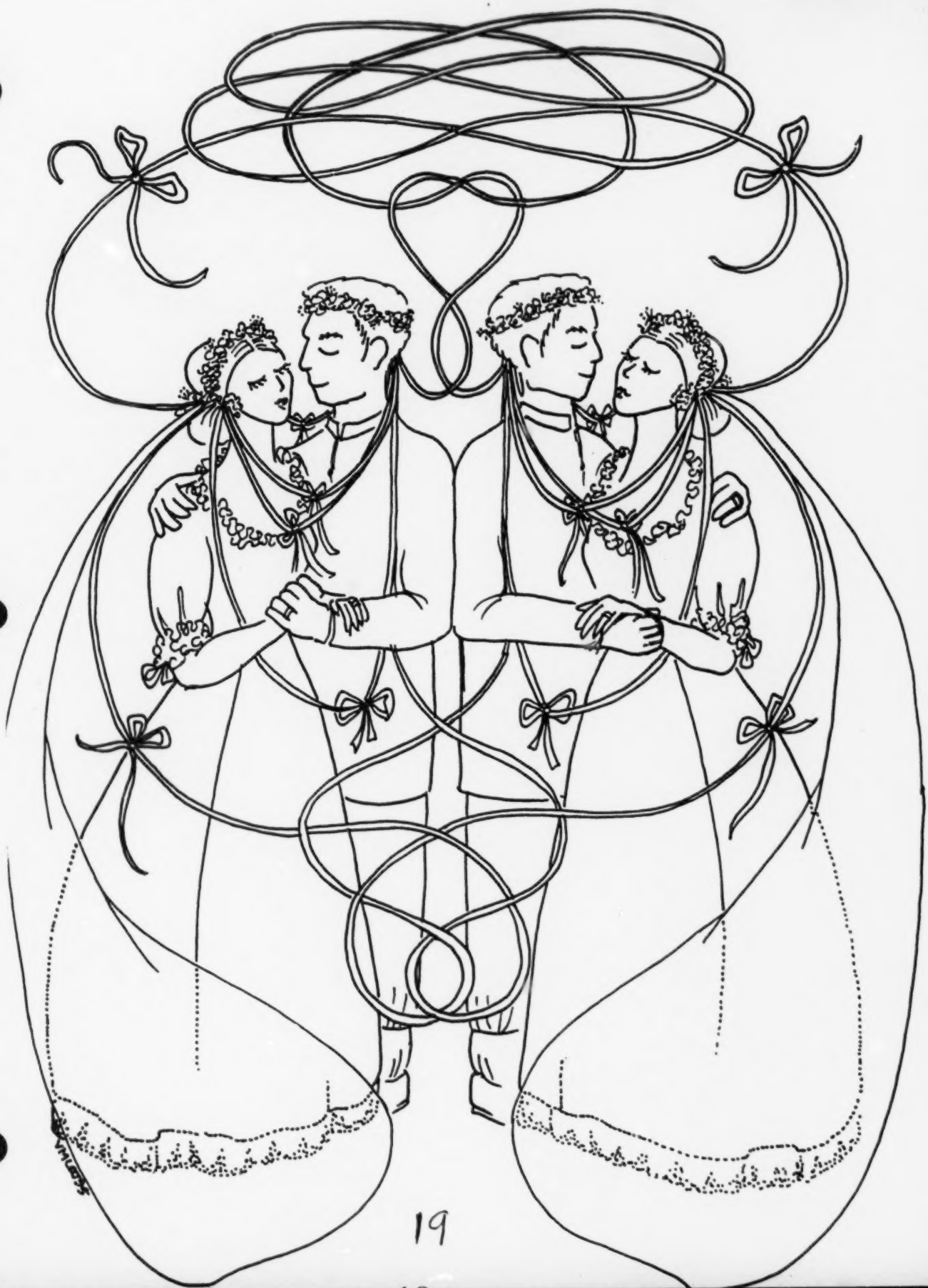
the end

Teacher Explanation

The teacher explains covalent molecular bonding in the traditional way. Weave in the allegory that molecules of hydrogen and bromine are like the brides and grooms respectively. The bonds are formed by the sharing of electrons, like the exchanging of rings. When the atoms are bonded together, as when the knot has been tied - the new joined entity is given a new name. A double wedding is appropriate for the twins since:

$$H_2 + Br_2 \rightarrow 2HBr$$

BEST COPY AVAILABLE



Stretch Break - "Tell a Partner"

YOU NEED
Music - 2-3 minutes fairly lively but played quietly.

You say:

Take a deep breath . Stand up.

In a moment I am going to start some music. While the music is playing I want you to find a person you don't normally sit next to. When the music starts, join that person (if necessary introduce yourself). Explain what you have learnt about covalent bonding to each other.

In two minutes, when the music finishes you are to go back to your normal seat.

Does everyone understand? Are there any questions? Then - let's do it!

Notes from Textbook

Use your regular textbook to make notes on all the points mentioned by the teacher. This may be given as homework.

SIMPLIFIED PERIODIC TABLE
MOLECULAR ELEMENTS - NONMETALS - QUESTIONS

On the periodic table below

- **shade in the elements that exist as molecules in a <u>colour</u>, and complete the key to match**
- **write the formula of the molecule in the appropriate square**
- **Indicate the "star performer" i.e. the most reactive nonmetal.**

key

- **metals**
- **nonmetal molecular elements**
- **other allotropes exist**
- **most reactive nonmetal**

									1 H								2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr																	

BEST COPY AVAILABLE

TEACHER'S PAGE - EXPLANATION OF CLASSIFICATIONS

In the diagonal band between the metals and non-metals there is some debate over the classification of some elements. Where there are several allotropes, each allotrope has a differing structure to that of the other(s). This variety of properties makes a good talking point for a discussion on bonding, properties and structure. The main forms are summarised below.

SOME SPECIAL ELEMENTS

No	Name	allotrope or form	mPt °C	bPt °C	conductivity MSm^{-1}	structure
6	carbon	diamond	>3550		10^{-17}	diamond network
		graphite	*3727	s3642	0.07	layers of hexagons
		"buckyball' (yellow)		s300-400 in vacuum	semi-conductor	C_{60} spherical hollow molecule.face-centd. cubic in solid
8	oxygen	diatomic	-219	-183	insulator	O_2 molecule
		ozone	-193	-111	insulator	O_3 molecule
15	phosphorus	white	44	280	10^{-15}	tetrahedral P_4 molecule
		red	*590	s417		chains
		black				polymer of layers
16	sulfur	rhombic	113	445	10^{-21}	S_8 ring molecules in crystals
		monoclinic	119	445		S_8 ring molecules in needle-like crystals
33	arsenic	yellow	d358			unstable As_4 molecule
		grey	*817	s613	3.9	polymer of layers
34	selenium	red	d170			unstable Se_8 ring molecule
		grey (metallic lustre)	217	685	8 in light (insulator in the dark)	long spiral chains
50	tin	white	232	2602	8.5	metallic
		grey	only at	low temps	poor	unstable diamond network
51	antimony	silver	631	1635	2.3	metallic-like network like black phosphorus
52	tellurium	silver	450	990	10^{-4}	long spiral chains

symbols used

* melts under pressure

s sublimes

d decomposes to another form

blank means no data available

SIMPLIFIED PERIODIC TABLE
MOLECULAR ELEMENTS - NONMETALS

key

- metals
- nonmetal molecular elements
- other allotropes exist
- * most reactive nonmetal

1 H_2									2 He
				5 B	6 C	7 N_2	8 O_2	* F_2	10 Ne
				13 Al	14 Si	15 P_4	16 S_8	17 Cl_2	18 Ar
27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As_4	34 Se_8	35 Br_2	36 Kr
45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I_2	54 Xe
77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At_2	86 Rn

BEST COPY AVAILABLE

Bonding Game 1 - " 20 Questions"

You need:

Set of bonding game cards - pages 1 & 2 - per group of 5 students (they could cut them up if you provide photocopies)

What you do:

Group of five students has a deck of bonding game cards face down in the middle.
One person takes a card off the top, but doesn't show it to anyone else. The others ask yes/no questions to discover what is on the card. A maximum of 20 questions may be asked. If nobody gets it after 20 questions the card-holder must show the card, then take another one and the askers try again.

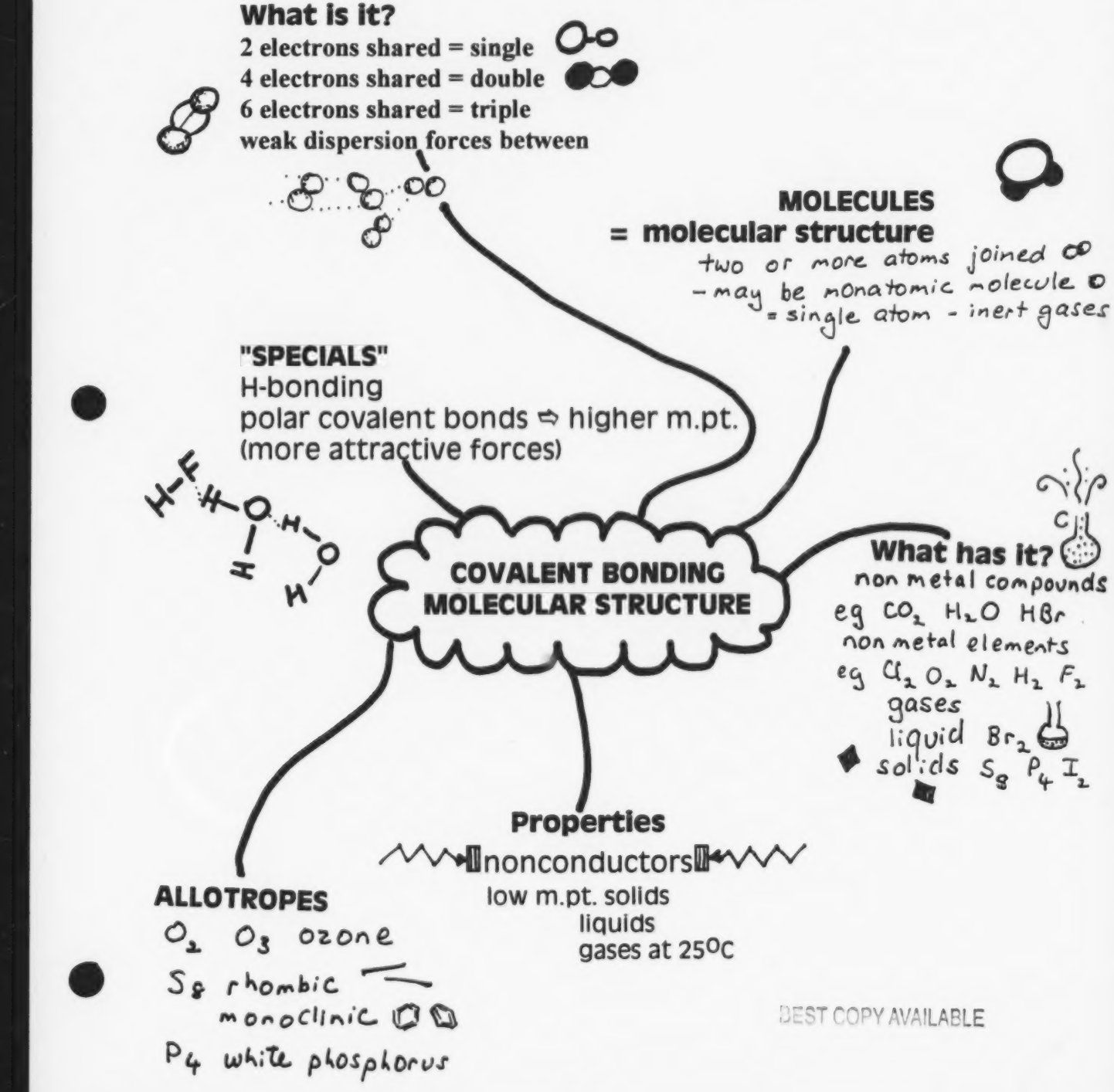
The successful asker takes the next card off the top of the deck. The game continues until cards are exhausted, or until all participants have had a turn, or until 10 cards have been guessed, depending on how much time you have allocated.

ATOM	GASEOUS ELEMENTS
H_2	DIATOMIC MOLECULE
POSITIVE ION	DELOCALISED ELECTRON CLOUD
METALLIC BONDING	COVALENT MOLECULAR BONDING

DOUBLE BOND	**ALLOTROPE**
OZONE O_3	**FRANCIUM**
HALOGENS	**ELECTRON PAIR**
DISPERSION FORCES	**FLUORINE**

Mind Map - Molecular

Students, either individually or in small groups, make a summary poster on a large piece of butcher's paper using thick textas. Three colours at least are to be used. The main concept is placed in the centre. Join other points to the main one with lines. Decorate the poster with relevant diagrams and symbols. It may look something like the one below.



BEST COPY AVAILABLE

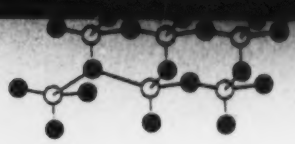
Molecular Rap

Molecules are tiny and separate
Dispersion forces are not so great
In liquid state they tumble round
Covalent bonds within are found
The melting point's low and so you see
They're often a gas at 25C
They can be elements or compounds too
But never with a metal 'cause that's taboo
They won't conduct a current 'cause the electrons
Are stuck inside the very strong covalent bonds.

Covalent bonding - network structure

Suggested Sequence -

- Introductory story read to music. *Academic Festival Overture Op80* by Brahms is excellent. *Allegro Vivace* from *Carmen Suite No 2* by Bizet is very good. Both are available at reasonable cost in the Best-Loved Classics series of CDs.
- Traditional explanation of covalent bonding - network structure, using the parable to assist in description.
- Stretch Break. "Tell a Partner". (Follow same idea as on page 5)
- Students make notes using their textbook. (May be given as homework)
- Colour-in periodic table with examples and "star performer".
- Bonding game 2 - "What am I?".
- Mind map summary of the concepts and examples.
- Rap summary.



The Rise and Fall of an Acrobatic Troupe

a parable of covalent network bonding

(about 3-4 minutes reading time)

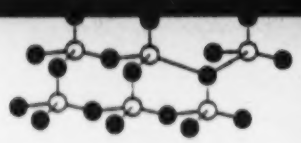
Once upon a time there were two very large groups of acrobats. One of them had about forty members but it had began as a small family group of an Italian called Con. The group had grown over the years with the addition of cousins and brothers and their wives. They were a very good group of acrobats and they practiced very hard. Their special, very famous routine had all the group in the circus ring at one time. They were dressed as clowns and they ran in and jumped onto the clowns at the base and made a large pyramid several people high - standing on the shoulders of those below. Because of this special pyramid act dressed as clowns, Con's acrobatic troupe became affectionately known as ***Silly Con's*** group.

Silly Con's group had a rival group who used to fight them getting jobs at the travelling circus when it came to town. The rival group, called the ***Flashing Diamonds***, was similar in size and also had a similar spectacular pyramid act. All of the ***Flashing Diamonds*** however were men. The ***Flashing Diamonds*** badly needed to get the next job for themselves. The ***Diamonds*** sent two saboteurs to the ***Silly Con's*** dress rehearsal audition, which was held in front of an audience, to make sure that the audition would be unsuccessful. Con's acrobats, by the way, always put on special ballet-type shoes then put their feet and hands in a special powder to increase their grip just before going into the ring. This is what the ***Diamond*** saboteurs did: They put superglue (an unusual type with time delay activation) inside the ballet shoes and mixed superglue with the special powder. Before the ***Silly Con's*** ran on they slipped into their ballet shoes and covered their hands and shoes with the special powder. They then ran on and did the wonderful pyramid with many acrobats on top of each other in their colourful costumes. The superglue stuck fast at this moment in time and fixed each acrobat into his or her shoes and fixed them to the shoulders of the acrobats below them, and fixed their hands to the acrobats at the side and above them.

The audience applauded wildly at the marvellous routine. Then it was time for the pyramid to come down. The top ***Silly Con's*** could not jump down because they were stuck. The side ones were stuck too - in fact they were all stuck to each other. The ringmaster suggested that some strong lion-tamers push on the bottom of the pyramid to break it. This was done and the whole pyramid fell over but still it did not break apart. They were all bonded to each other very strongly. The group was becoming very distressed. Some of the lady acrobats started to cry. All the circus goers had gone home and most of the lights had been turned off. But still the group could not separate.

Finally, in desperation, a desperate measure was agreed on. They decided that steel chisels and hammers would be employed to physically break the superglue connections. This was then done, but at a terrible cost. ***(overhead illustration)**

STAR
TRACT
LASH
DIAMO



Leather was ripped from shoes and skin was torn from fingers as the members were separated from each other by strong swift blows on the hammer.

Many of the ***Silly Con's*** group were so injured they could never work again. Some were disillusioned by their ordeal and formed smaller networks. One group of cousins dyed their hair blond and made their own small group called the ***Sandy Grains.*** Another breakaway group amalgamated with a hot rock group and called themselves the ***Concretes.***

The ***Flashing Diamonds*** succeeded in their evil plan and they went on to become the most famous acrobatic group in the world. Their glittering display gave them a perfect score of 10 at the World finals and they won the coveted Moh award at the Olympics.

the end

The Explanation

The teacher gives a traditional explanation of covalent network bonding, weaving in the allegory that silicon and oxygen atoms in silica (silicon dioxide) are like the men and women in ***Silly Con's***. They are bonded strongly in a 3-D lattice like the way the acrobats are stuck in their pyramid.

Silica, though stongly bonded, is brittle, and can be shattered by a hammer, like the way the ***Silly Con's*** can be separated. Small fragments of silica make sand. Sand can be combined with baked limestone, like a hot rock group, to make concrete.

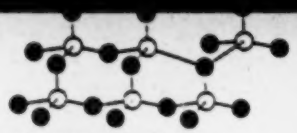
The all male ***Flashing Diamonds*** are like the the carbon atoms that make up a diamond lattice. On Moh's scale of hardness, the diamond is 10 - the hardest naturally occurring substance.

Stretch Break - "Tell a Partner"

Follow same method as on page 5

Notes from Textbook

Use your regular textbook to make notes on all the points mentioned by the teacher. This may be given as homework.



SIMPLIFIED PERIODIC TABLE
NETWORK QUESTIONS

On the periodic table below

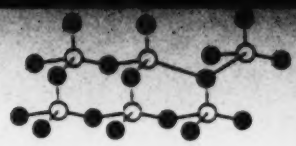
- **Indicate according to the key, and from the overhead, the network covalent elements.**
- **List the names and symbols of 4 network elements and 2 network compounds**
- **Indicate the "star performer" i.e. the element with the strongest network lattice.**

key

-covalent network

- a chain form exists

									1 H								2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr																	



SIMPLIFIED PERIODIC TABLE NETWORK

key

✖ - covalent network

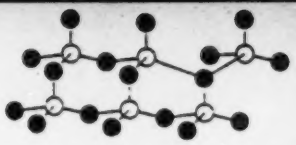
✕ - a chain form exists

carbon-diamond "star performer"

									1 H								2 He
3 Li	4 Be											✖	✖	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	✖	✕	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	✖	✖	✕	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	✖	✕	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr																	

covalent network compounds

silicon carbide	**SiC**
silicon dioxide	**SiO_2**
tungsten carbide	**WC**



Bonding Game 2- "What am I?"

You Need:

Set of bonding game cards - pages 1,2 & 3 - with hole punched in top of each one.
Small safety pins.

What you do:

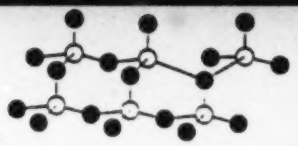
Distribute a card and a safety pin to each student. The student then pins the card to the back of another student, without that student seeing the writing on the card.

Each student then goes around the room and asks one yes/no question of another student to determine the term on his or her back. The first few students correctly identifying their label could be given an edible reward.

ATOM	GASEOUS ELEMENTS
H_2	DIATOMIC MOLECULE
POSITIVE ION	DELOCALISED ELECTRON CLOUD
METALLIC BONDING	COVALENT MOLECULAR BONDING

DOUBLE BOND	**ALLOTROPE**
OZONE O_3	**FRANCIUM**
HALOGENS	**ELECTRON PAIR**
DISPERSION FORCES	**FLUORINE**

TUNGSTEN CARBIDE	**EMPIRICAL FORMULA**
DIAMOND	**WHITE PHOSPHORUS P_4**
COVALENT NETWORK LATTICE	**RED PHOSPHORUS Chain Structure**
BLACK PHOSPHORUS polymer	**SILICON**

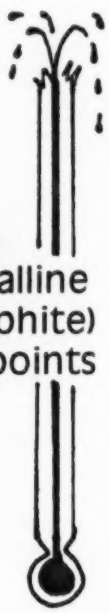


Mind Map - Network

Students, either individually or in small groups, make a summary poster on a large piece of butcher's paper using thick textas. Three colours at least are to be used. The main concept is placed in the centre. Join other points to the main one with lines. Decorate the poster with relevant diagrams and symbols. It may look something like the one below.

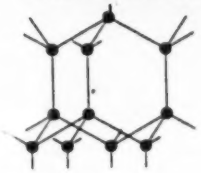
WHAT HAS IT?
Elements near the metal--non-metal dividing line
metalloids and non-metals that can form many bonds

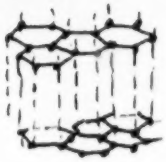
PROPERTIES
brittle, hard, crystalline
non-conductors (except graphite)
high melting and boiling points



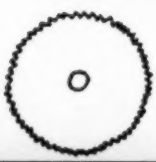
NETWORK STRUCTURE
COVALENT BONDING
giant molecular

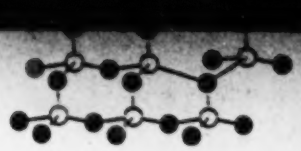
ALLOTROPES of C
diamond, graphite





COMPOUNDS
SiC, SiO_2 ,WC
must use empirical formula
used as abrasives



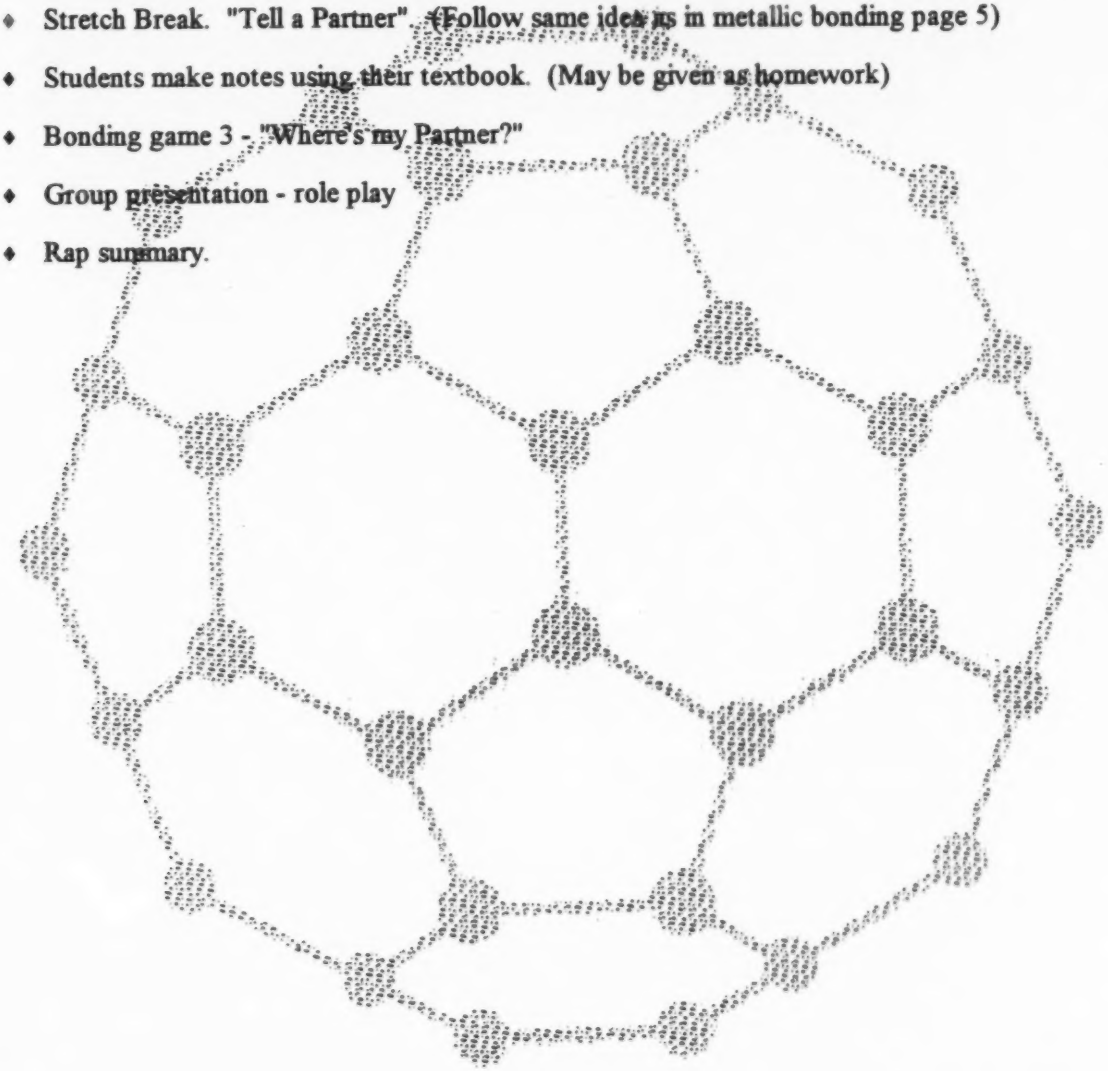


Network Rap

In network covalent we find that there are
Atoms in a lattice that's regular
They're all bound together by covalent bonds
It's quite a simple concept- shared electrons
Separate molecules - there are none
But an infinite network, yes there is one
Diamond's an example and its really hard
Just try and scratch the surface - its rarely marred
Silicon dioxide - sand to you
Is another example of a network too
The formula for them is empirical
If we were in English it'd be satirical
The way that they conduct is very poor
And they are all solids at high temp'rature
Network substances are very brittle.
Our rap is quite long - now its not so little.

Ionic bonding
Suggested Sequence -

- Introductory story read to music. (Excerpts from Tina Turner ***Disco Inferno*** or a rock instrumental recommended)
- Traditional explanation of ionic bonding , using the parable to assist in description.
- Stretch Break. "Tell a Partner". (Follow same idea as in metallic bonding page 5)
- Students make notes using their textbook. (May be given as homework)
- Bonding game 3 - "Where's my Partner?"
- Group presentation - role play
- Rap summary.



The Ionic Bonding Concert

a parable of ionic bonding

Once upon a time there was a young, but silver-haired girl called Sophie. She was a keen fan of heavy metal rock bands and indeed, she and her sisters, Nadine and Alki, had a rock band themselves. Sophie and her sisters Nadine and Alki always dressed in silvery clothes and even silvery shoes and tights, sparkly nail polish, earrings - everything! Sophie, like her sisters was a very active, energetic, hot-blooded girl. Her love of the opposite sex had led some unkind souls to call her a nymphomaniac. She certainly did seem to have a strong need to be close to and physical with guys. Sophie, Nadine and Alki were well liked by the guys in the football team who said that Sophie and her sisters were all generous, giving girls.

Chlorry wasn't a footballer and he wasn't into heavy metal music so it was a wonder that he ever met Sophie. Chlorry was a "greenie" - a keen bushwalker and a serious science student who was studying Environmental Chemistry and Marine Biology. Chlorry met Sophie at the crystal shop. Chlorry wanted a crystal of rock salt to complete his collection. Sophie only wanted some new sparkly earrings to wear to the rock concert that night. They were introduced by one of the footballers who was a friend of Sophie's and also in Chlorry's bushwalking group. The footballer asked Chlorry to do both himself and Sophie a favour and made Chlorry an offer that he couldn't refuse.

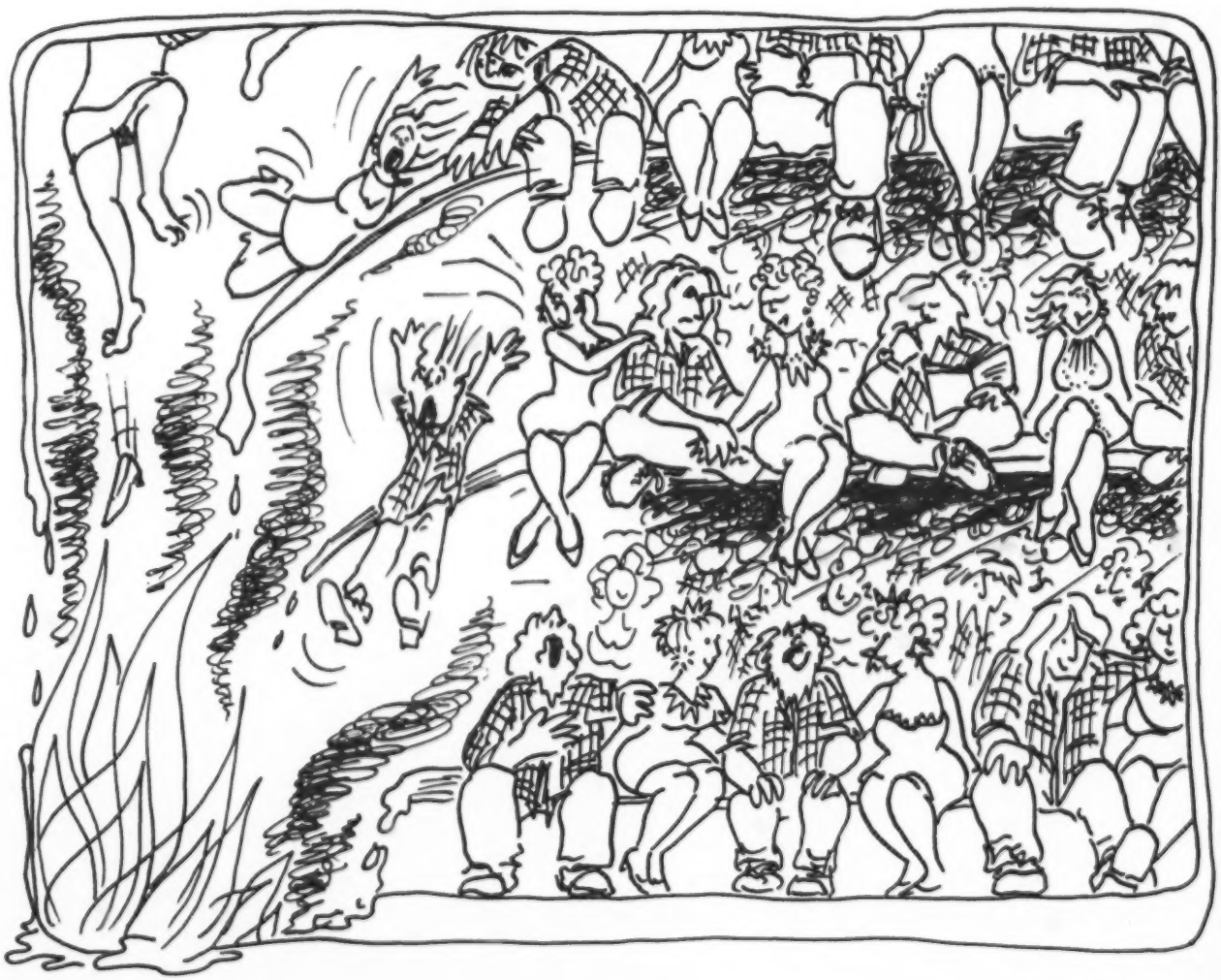
The football team, it seemed, had lost their match that Saturday, and were all suffering bruises, cut heads, broken noses, pulled hamstrings and groin injuries. Although several of the footballers had promised to take Sophie and her sisters to the rock concert they just didn't feel up to it . Chlorry was asked if he and some of his greenie friends could partner the girls that evening. Chlorry readily agreed and it didn't take long to organise a large and very excited, though rather odd-looking group to go to the concert. The girls in their sparkly outfits and the very excited guys in their hand-knitted sweaters and corduroy pants or khaki shorts worn with hiking boots - well - opposites attract so they say.

They went to see a fabulous new group called ***Ionic Bonding*** that was playing at the big new stadium called the Crystal Lattice. Chlorry held their ticket because he had lots of pockets in his clothes. (The management only required that the tickets were shown at the door; they didn't have to hand them in) Sophie and her sisters and Chlorry and the greenies took their seats in the Crystal Lattice. Chlorry was a bit nervous to find that their seats and the floors were made of thin, tubular frames and you could see straight through them. The Crystal Lattice management had tried to pack in as many as they could and the seating was tiered in many layers. Sophie was thrilled to have Chlorry on one hand, a mate of his on the other, one above her and one below her, another in front and one behind. Sophie was surrounded with the opposite sex on all sides! She had never been so happy! Chlorry also could feel Sophie and her sisters on three sides and could see more lovely girls through the floor above and below him, and could feel the warmth of another behind him. He too had never been so happy!

Ionic Bonding had begun and all the boys and girls were very happy in the Crystal Lattice. The whole place was humming and vibrating to the music.

But then the Crystal Lattice started heating up. A fire had started in one corner and it seemed some of the seating in that corner was sagging.(* **overhead illustration)**

* CRYSTAL LATTICE FRAMEWORK STARTS MELTING.



Suddenly the heat was overwhelming and the framework gave way spilling the boys and girls everywhere.

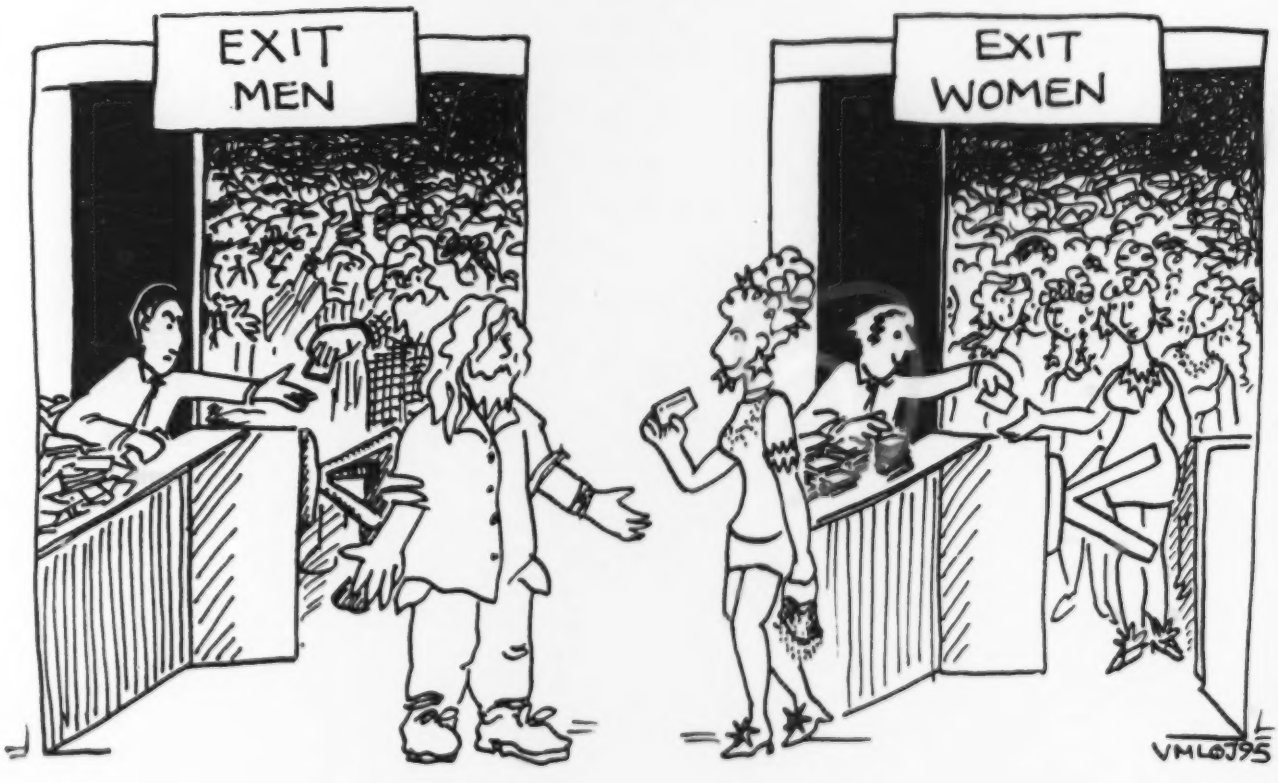
The fire spread, Sophie's seat melted and she fell to the ground. She lost touch with Chlorry and his friends. Young people were running around everywhere and even treading on and crawling over each other. Sophie forgot about her need to be close to anyone in the rush to find a way out.

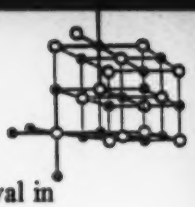
When the kids could look up they saw two signs:

EXIT MEN	and	EXIT WOMEN

Sophie and her sisters joined the other girls heading towards the EXIT WOMEN sign and they could see a doorway with girls streaming through. **(** overhead illustration)**

** SEPARATE EXITS FROM THE CRYSTAL LATTICE





As they escaped, ushers handed them pass-out tickets like the ones given at interval in some shows. Sophie took the ticket pressed into her hand, but even at the time thought it was stupid. She didn't think either she or any of the girls would return to that place.

Meanwhile, Chlorry and his mates hurried to the EXIT MEN door. Ushers collected their tickets at the doorway and would not allow them to go out unless they handed it in. Despite all the pushing and confusion the exit happened pretty smoothly. The manager made sure that equal numbers of boys and girls left at the same time, even though they were leaving by different doors.

Outside the Crystal Lattice, Sophie met up again with Chlorry. She felt transformed by her experiences, but he just looked green and seemed ready to faint. She was so happy to see him that she forgot about any bad experiences in the Crystal Lattice. They both agreed the ***Ionic Bonding*** was fantastic and they would go again at the next opportunity.

the end

Teacher Explanation

The teacher explains ionic bonding in the traditional way, weaving in the allegory that positive (alkali) metal ions are like Sophie, Nadine and Alki. Negative chloride ions are like Chlorry and his friends . In the crystal lattice, ions are packed closely together as the kids were at the concert - each ion being surrounded by 6 ions of opposite charge - front and back, side to side as well as up and down.

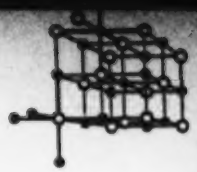
When the crystal lattice heats up, the ions are free to move and tumble over each other and the crystal melts, like the kids falling out of their seats and crawling over each other when there was a fire in the Crystal Lattice stadium. Positive metal ions are attracted to one electrode - like the EXIT WOMEN - and negative ions to the opposite one. The negative ion gives up its electron - like Chlorry's ticket - when leaving the molten salt. The positive ion is given an electron to transform it into a metal atom at the electrode. Equal numbers of electrons must be given and received at the electrodes - as the management ruled in the Crystal Lattice stadium.

Stretch Break - "Tell a Partner"

Follow method on page 5 Metallic Bonding.

Notes from Textbook

Use your regular textbook to make notes on all the points mentioned by the teacher. This may be given as homework.



Bonding Game 3-
"Where's My Partner?"

You Need:

Set of **matching** bonding cards - pages 4,5 & 6 following - with hole punched in top of each one.
Small safety pins.

What you do:

This game is played similarly to Bonding Game 2 in the previous section page 27.
However, once the student has correctly guessed the term on his/her back, he or she must find the matching partner, then report to the teacher.

Monatomic molecule matches with Helium atom for example.

The first few pairs back to the teacher could be given an edible reward.

MONATOMIC MOLECULE	**HELIUM ATOM**
METALLIC BONDING	**DELOCALISED ELECTRON CLOUD**
POSITIVE ION	**Na^+**
ELECTRO-NEGATIVE ELEMENT	**FLUORINE**

MATCHING BONDING GAMES CARD PHOTOCOPY PAGE 5

GRAPHITE	CARBON ALLOTROPE
MOST METALLIC ELEMENT	FRANCIUM
DOUBLE BONDS	O=C=O
EMPIRICAL FORMULA	NaCl

MATCHING BONDING GAMES CARD PHOTOCOPY PAGE 6

GIANT NETWORK COMPOUND	SILICON CARBIDE
SOLID CONDUCTOR	METAL
POLYATOMIC CATION	NH_4^+
POLYATOMIC ANION	NO_3^-

Group Presentation - Role play

Time needed: about one hour

You need:

'Things' for costumes and props eg.
butchers' & coloured paper, sticky tape,lengths of coloured cloth, hoops, balls rope, wool etc

Tape player with special effects tape for fanfare introductions (see sources page)

Prepare the class in groups of 5.

You say:

You have now had many lessons on the important topic of chemical bonding and structure. In your group, I would like you to choose any aspect of any type of chemical bonding.
Then I want you to decide on a way to illustrate or show this aspect by doing a presentation in your group.

The presentation should last about 2 or 3 minutes. You may use some of the materials out the front if you wish. You will have about half an hour to prepare your presentation, and then we will see the items. You will need at least one person to explain the item to the rest of the class afterward, to help us understand what's going on.

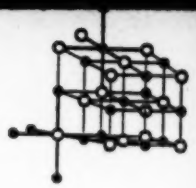
Are there any questions? Then - lets do it!

Then:

Give them about half an hour to prepare and practice. Then call the groups to attention and ask for a volunteer group to start. Play a fanfare before each group comes on.

Give plenty of positive feedback for each item.

The "explainer(s)" from each group answers class questions if necessary after each performance.



Ionic Rap

A metal and non-metal make up this bond,
The electrical attractions are very strong
The electrons are transferred from one to the other
Sort of like a gift from a sister to a brother.
The temperatures they melt at are very high,
but they'll break if you hit them if only you'll try.
When they're in solution or in liquid state,
They conduct a current at a very fast rate.
'Cause you know it's ions the charge they carry
Not the electrons - did ya get that Barry?
And one last thing - ions are bound in a lattice
Attraction of the opposites that's all that matters!

Structure

Now you know about the bonds and
chemical structure
But there's H-bonds and polar things
just to disrupt ya
There's weaker bonds and stronger bonds
but always remember
The chemical rap is here to defend ya!